

PATENT SPECIFICATION

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(54) FLUID DISTRIBUTION AND CONTACTING ELEMENTS

- (71) We, MIDLAND WIRE CORD-
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 B17 9BJ, both British Subjects, do hereby
 10 declare this invention to be described in the
 following statement:—
 This invention relates to articles suitable
 for use as packing elements in a tower, column
 or chemical reaction vessel so as to enhance
 15 interaction between fluids, or a fluid and a
 solid, moving in counter-current or co-current
 flow through the tower, column or vessel, or
 to de-entrain solid or fluid from a fluid flow
 through the tower or column, as required in,
 20 for example, fractionation, distillation, ab-
 sorption, humidification, liquid-liquid extrac-
 tion, chemical reaction etc.
 According to a first aspect of the invention
 we provide fluid-fluid or fluid-solid contacting,
 25 de-entrainment or reaction apparatus, com-
 prising a column, which may extend substan-
 tially vertically, or a reactor vessel, and a
 plurality of the articles distributed randomly
 within said column or vessel, each article
 30 comprising a skeletal structure comprising at
 least two elongate members twisted together
 to form a central core, and a plurality of
 convolutions having portions thereof trapped
 within the gaps between the core members
 35 and held thereby in a configuration such that
 the convolutions collectively extend in helical
 fashion about the central core.
 The core members are conveniently con-
 stituted by lengths of wire or alternatively a
 40 single length of wire bent at one or more
 positions intermediate its ends to provide two
 or more substantially coextensive portions.
 The convolutions are preferably formed from
 a plurality of filaments of, for example, wire,
 45 which may be of round section or non-round
 section, for example semi-circular, square or
 rectangular section, each filament forming a
 respective loop portion of each convolution.
 The filaments may all be of the same mat-
 erial, for example, wire, or different materials,
 for example, wire, plastics material or glass
 fibre. In some instances, the convolutions may
 be formed from a single filament, e.g. for
 certain specific de-entrainment applications,
 but otherwise it is preferred to use a plurality
 55 of intertwined, e.g. twisted together, filaments,
 and the number of filaments may be for
 example between 3 and 9 and preferably
 is 5—6.
 The convolutions may be of generally cir-
 cular configuration including the possibility
 of joining a loop from a crimped element
 so that the loop is a multi-pointed star shape
 but other configurations, formed from linear
 or crimped wire, for example, square, are
 65 possible. The central core defined by said
 twisted members may be generally rectilinear
 or it may be arcuate or consist of a number
 of angularly related sections so as to adopt
 an open or closed loop configuration or a
 70 sinuous configuration.
 According to a second aspect of the in-
 vention we provide an article for use as a
 packing element, said article comprising a
 skeletal structure comprising at least two
 75 elongate members twisted together to form
 a central core, and a plurality of convolutions
 having portions thereof trapped within the
 gaps between the core members and held
 thereby in a configuration such that the con-
 80 volutions collectively extend in helical fashion
 about the central core, characterised in that
 each convolution comprises at least two inter-
 twined loop portions.
 According to a further aspect of the in-
 85 vention we provide a method of making an
 article according to said second aspect of the
 invention suitable for use as packing elements
 in the apparatus according to said first aspect
 of the invention, said method comprising
 90 twisting a bundle of filaments together to
 make a twisted bundle, winding the bundle
 to make a coil, and locating first and second
 core members respectively within and with-
 out the coil so as to extend generally parallel
 95 to the axis of the same, and twisting the core
 members so that the convolutions of the coil
 extend in generally helical fashion about the

twisted core members, with the filaments of each convolution intertwined with each other.

The initial twisting to form the bundle may be relatively loose so that, in the final product, the filament portions defining each convolution separate slightly from one another and are effective to entrain fluid therebetween by a capillary wetting action. The product of the method may be formed in a length suitable for immediate use as a packing element (after manipulation to form an open or closed loop configuration or a sinuous configuration if desired) or alternatively the product may be made of great length and subsequently severed into a number of shorter lengths suitable for use in a column.

In a modification, for use for example in making packing elements for certain specific de-entrainment application, the above-defined method is simplified by using a coil wound from a single filament.

As mentioned previously, the filaments may be of metal wire of round or other section. The dimensions of the filaments, the convolutions formed thereby and the core members are selected to provide a large surface area for fluid contact within a given volume of the tower or column. Preferably the diameter and transverse dimensions of the filaments will be less than those of the core members but to avoid maldistribution effects the core members will have a relatively small diameter otherwise there may be a pronounced tendency for fluid flow to take place along the central core.

The hardness and resilience of the metal used for the filaments may depend upon the required application, but in general these parameters will be higher for the filaments than for the core members so as to ensure that the filaments spread and separate very slightly from one another in the finished product.

In order to improve the degree of fluid contact, the wettability of the convolutions of the packing elements may be enhanced by coating, covering or treating the same with a material having good wettability properties. Thus, for example, each filament may be enclosed within a sheath of woven glass fibre, the interstices between the woven fibres serving to retain fluid on the convolutions of the packing elements, or the filaments may be etched.

Reference is now made to Figures 1 to 5 of the accompanying drawings to illustrate the invention.

Fig. 1 shows a bundle of, in this case, three filaments loosely entrained to form a bundle.

Fig. 2 shows the next stage in which the bundle has been wound into a loose coil with eyes at each end for convenience in the subsequent steps.

Fig. 3 shows the provision of a U-shaped length of wire having one limb within the other limb without the coil. The limbs of

the U-shaped wire are twisted around one another to trap the coil convolutions therebetween and cause them to be displaced about the central core in helical fashion as shown in Figs. 4 and 5. It will be seen from Fig. 5 that the individual filament portions defining each convolution are separated from one another to provide a capillary action, and the end eyes may be cut-off.

The product of the above steps is finally severed into a plurality of discrete parts which may then be packed randomly within the column of a fluid contacting or de-entrainment apparatus.

Typically severed portions when of substantially rectilinear configuration will be about 38mm in length. In the example, the article was formed from a bundle of three wires each 0.32 mm diameter twisted together with a left hand lay of about 8 mm and the bundle so formed was wound to form a coil of approximately 9 mm outside diameter. The diameter of the length of core wire was approximately 0.5 mm. It was found that elements having these dimensions could be packed firmly, and randomly, within a column of for example nine inches diameter, without any significant interlocking between the elements thereby allowing ready removal thereof for re-use.

Experimental work has been carried out to compare the efficiency of the packing elements according to the present invention with known packing elements and it has been found that significant improvements are obtained both with elements produced from two filament, three filament and five filament bundles, the more significant improvement being obtained with higher numbers.

It is believed that five to six filaments represents an economic optimum. Moreover, the experimental results show substantial consistency, that is to say the results are repeatable when the elements are removed and repacked. Using straight lengths of the elements it is found that the random packing produces a high proportion disposed generally horizontally or at small angles to the horizontal.

It is thought that the improvements stem from the relatively large surface area provided for fluid contact by the multi-filament convolutions both in terms of the actual surface area of material available and by virtue of the aforesaid capillary wetting action. A notable feature apparent from the experiments made is that the pressure drop across the mass of packing elements is relatively low compared with conventional packing arrangements and furthermore it has been found that the packing elements according to the invention provide good efficiency even at low reflux ratios (i.e. liquid to vapor ratio of < 0.5 to 0.8) in, for example, an ethyl alcohol-propyl alcohol system. The packings of the invention have a wide application and are particularly suitable

where low pressure drop is important as in vacuum distillation and for those cases of absorption where the liquid rate is low and the gas or air flow high.

5 Whilst significant improvements have been obtained using multi-filament convolutions, it is contemplated that improvements may be obtained with single wire filament convolutions if the filament is either coated or sheathed with a material such as glass fibre to improve the wettability thereof, or if the filament is composed of a material having good wettability properties.

10 It will be understood that the packing elements could be made by a method other than that described above; in particular they could be made in automatic or semi-automatic machinery in continuous length and cut into pieces, and in such case the end loops needed for the illustrated method would not be required.

Examples of experimental results using the invention are as follows:—

Example 1.

25 A 9 inch diameter column of 4.5 ft. height was used for fractionating methylcyclohexane toluene at total reflux and at a boil-up rate of 800 lbs/ft²-hour. The column was packed with elements as in Fig. 5, but made with 5 filaments and in 1.5 inch lengths. The total pressured drop was 0.25 inches water gauge, and the HETP (Height Equivalent to Theoretical Plate) was 8.5 inches.

30 By comparison, 1" diameter metal PALL RINGS (Registered Trade Mark) used as packings in the same column/system gave a HETP of 10 inches, and a pressure drop of 0.5 inches.

Example 2.

40 In a 6" column of 3 ft height, with the same 5 filament packing elements, fractionating ethyl alcohol—a propyl alcohol at total reflux and a boil-up rate of 250 lbs/ft² low, the HETP was 8 inches. In comparison $\frac{3}{8}$ " metal PALL RINGS (Registered Trade Mark) in the same system gave a HETP of 11 inches. The packings of the invention gave a pressure drop of 0.08 inches of water/foot height at an air loading of 1000 lbs/ft² hour, and 0.26 inch water/ft at 2000 lbs/ft² hour of air. The pall rings comparison figures were 0.25 inches water/ft and 1.1 inch of water/ft respectively.

WHAT WE CLAIM IS:—

55 1. A fluid-fluid or fluid-solid contacting de-entrainment or reaction apparatus, comprising a column, which may extend substantially vertically, or a reactor vessel, and a plurality of articles distributed randomly within said column or vessel, each article comprising a skeletal structure comprising at least two elongate members twisted to-

gether to form a central core, and a plurality of convolutions having portions thereof trapped within the gaps between the core members and held thereby in a configuration such that the convolutions collectively extend in helical fashion about the central core. 65

2. Apparatus as claimed in Claim 1, wherein said articles comprise a wire core. 70

3. Apparatus as claimed in Claim 1 or Claim 2 wherein the convolutions comprise a plurality of filaments.

4. An article for use as a packing element, said article comprising skeletal structure comprising at least two elongate members twisted together to form a central core, and a plurality of convolutions having portions thereof trapped within the gaps between the core members and held thereby in a configuration such that the convolutions collectively extend in helical fashion about the central core, characterised in that each convolution comprises at least two intertwined loop portions. 75

5. An article as claimed in Claim 4 wherein said two elongate members are of a metal wire. 80

6. An article as claimed in Claim 4 or Claim 5 wherein said at least two intertwined loop portions comprise metal filaments. 85

7. An article as claimed in Claim 4 or Claim 5 wherein three or more intertwined loop portions are provided. 90

8. An article according to Claim 4 wherein five intertwined loop portions are provided. 95

9. An article as claimed in any of Claims 4 to 7 wherein the intertwined loop portions are formed from filaments of round cross-section.

10. An article as claimed in any of Claims 4 to 7 wherein the intertwined loop portions are formed of non-circular filaments. 100

11. An article as claimed in any of Claims 4 to 9 wherein the said core is generally rectilinear. 105

12. An article according to any of Claims 4 to 9 wherein said core is non-rectilinear.

13. A method of making an article as claimed in any of Claims 4 to 11 for use as a packing element in apparatus as claimed in any of Claims 1 to 3 comprising twisting a bundle of filaments together to make a twisted bundle, winding the bundle to make a coil, and locating first and second core members respectively within and without the coil so as to extend generally parallel to the axis of the same, and twisting the core members to form a skeletal structure in which the convolutions of the coil extend in generally helical fashion about the twisted core members, with the filaments of each convolution intertwined with each other. 110

14. A method as claimed in Claim 12 comprising the further step of severing the core to form a plurality of separate articles. 115

15. An apparatus as claimed in Claim 1 provided with a plurality of articles, said 120

articles being substantially as described herein with reference to, and as shown in, the accompanying drawings.

- 5 16. A packing element substantially as described with reference to, and as shown in, the accompanying drawings.

17. A method of making a packing element substantially as described with reference to the accompanying drawings.

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